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DEPLOYMENT ASSETS REQUIRED FOR SOUTHWEST ASIA ENGINEER CAPABILITY OPTIONS FOR HEAVY DIVISIONS

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13. ABSTRACT (Maximum 200 words)

The Office of the Chief of Engineers directed the Engineer Strategic Studies Center (ESSC) to complete a formal study that compared the 1990 fielded force (Base Case) to the 1999 Regimental Engineer case. The study scenario deploys five heavy divisions to Southwest Asia (SWA). The *Southwest Asia Engineer Capability Options for Heavy Divisions (SACAPO)* study was completed in September 1991. The SACAPO study compares manpower and equipment capabilities for all cases and times. During the SACAPO study a question was raised concerning the transportation assets required to move the engineer force to Southwest Asia. In this report, ESSC addresses those concerns by evaluating aircraft sortie and ship requirements for two unit designs--the FY91 engineer force (Base Case) and the 1990 E-force design (Regimental Engineer). This report rates the Base Case for 1990 and the Regimental Engineer case for 1999. The Military Traffic Management Command (MTMC) Transportation Engineering Agency computed the transportation requirements based on data provided by ESSC. This study's findings provide recommendations about the planning process for future engineer organizational structures.

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CONTENTS

EXECUTIVE SUMMARY

Between 1984 and 1990, the U.S. Army Engineer School designed and field tested a new engineer structure--"Division Engineer"--for the maneuver heavy division. This new structure provides an engineer battalion for each divisional maneuver brigade. The three small battalions have replaced two larger battalions--the older divisional engineer battalion and a supporting corps combat engineer battalion--with basically no change in total engineer strength.

Between 1989 and 1991, the Division Engineer concept became embodied within the Engineer Restructure Initiative. The revised structure--"Regimental Engineer"--is similar to, but smaller than, the Division Engineer. The Army approved the Regimental Engineer structure for implementation in the 1990s.

The Office of the Chief of Engineers directed the Engineer Strategic Studies Center (ESSC) to complete a formal study that compared the 1990 fielded force (Base Case) to the 1999 Regimental Engineer case. The study scenario deploys five heavy divisions to Southwest Asia (SWA). This study--*Southwest Asia Engineer Capability Options for Heavy Divisions (SACAPO)*--was completed in September 1991. The SACAPO study compares manpower and equipment capabilities for all cases and times. During the SACAPO study a question was raised concerning the transportation assets required to move the engineer force to Southwest Asia. In this report, ESSC addresses those concerns regarding the transportation requirements for engineer division and corps structures in 1990 and 1999. The Military Traffic Management Command (MTMC) Transportation Engineering Agency computed the transportation requirements based on data provided by ESSC. **Figure i** summarizes these basic findings by comparing the actual number of aircraft and ships required to move engineer forces in the division and corps sectors for 1990 and 1999 and by comparing these requirements in percentages, with the Base Case (1990) being 100 percent.

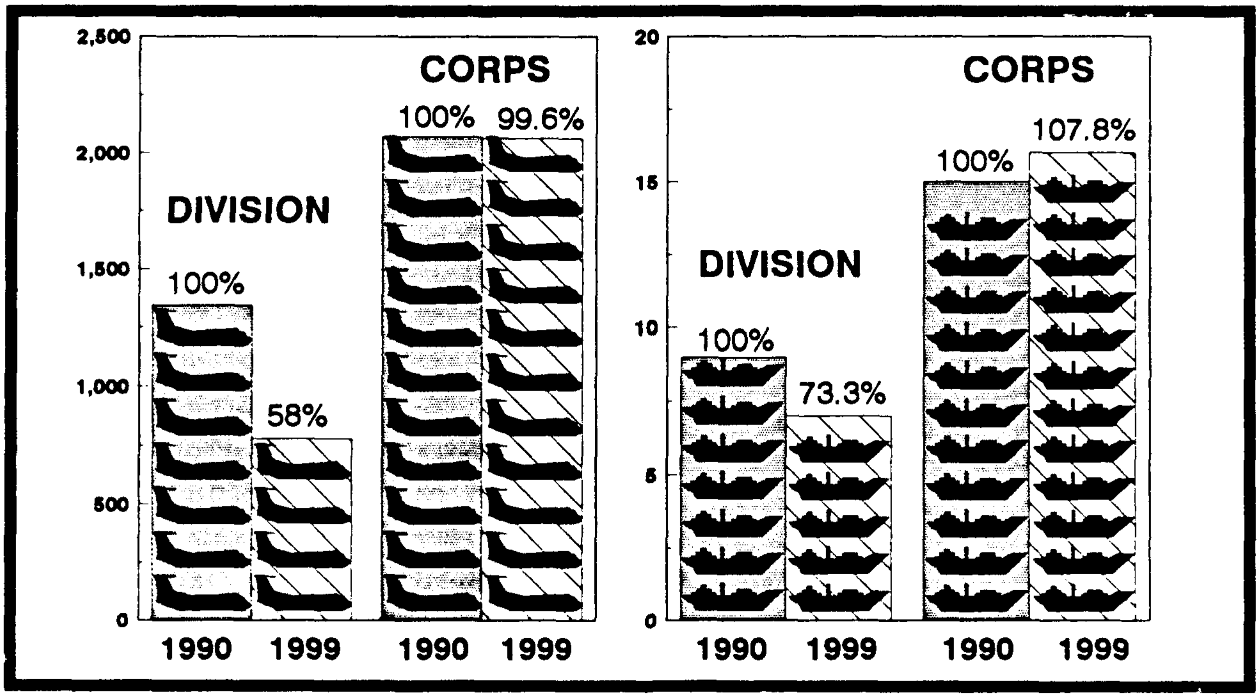

Figure i. COMPARISONS OF ENGINEER DEPLOYMENT FROM CONUS TO SWA (1990 AND 1999)

Considering these findings, ESSC makes the following recommendations:

- Mobility must be a key consideration in the TOE planning process. Participation with MTMC Transportation Engineering Agency in identifying realistic unit transportation requirements should be a standard part of TOE development.

- Continue reducing the Corps deployment requirements of a full 1999 Regimental Engineer division slice to match those requirements gained within the 1999 division zone.

I. INTRODUCTION

1. **PURPOSE.** This study determines and compares the assets required to transport designated engineer units and organizations to Southwest Asia (SWA) in support of heavy divisions.

2. **SCOPE.** This study determines the transportation requirements for six engineer alternative structures.

a. **Unit Design.** The study evaluates sortie and ship requirements for two unit designs. The FY91 force is the Base Case and the 1990 E-Force design is the Regimental Engineer case.

b. **Time Frame.** This study rates the Base Case for 1990 and the Regimental Engineer case as it will exist in 1999. ESSC used the Program Objective Memorandum (POM) to forecast new equipment and capabilities for the 1999 period.

c. **Unit Options.** The unit options evaluated in this report are division zone, division zone with a corps plug, and a division slice. **Figure 1** is a schematic diagram showing the battlefield location of these units.

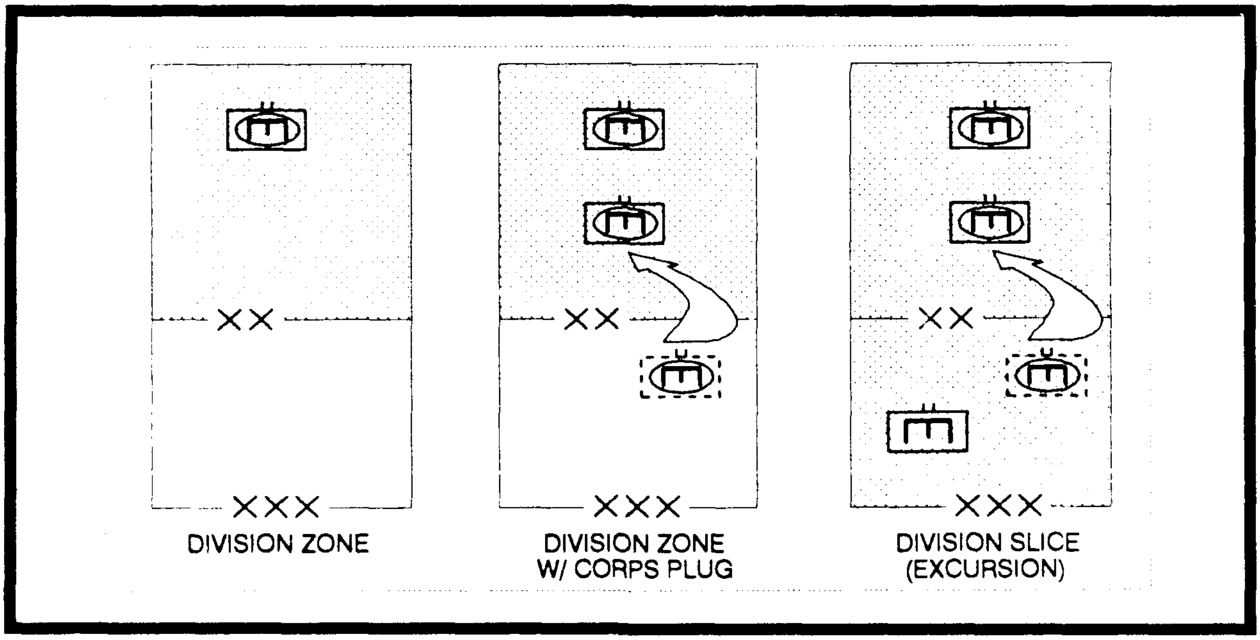

Figure 1. BATTLEFIELD LOCATION OF UNIT OPTIONS

(1) **Division Zone**--the organic Division Engineer organization plus one corps engineer battalion in the Base Case.

(2) **Corps Plug**--the divisional and corps units working forward of the divisional rear boundary.

(3) **Division Slice**--includes corps units of the corps plug and corps units behind the division rear boundary equally divided among the maneuver divisions.

3. BACKGROUND.

a. The Military Engineering and Topography Division of the Office of the Chief of Engineers requested a study on the *Southwest Asia Engineer Capability Options for Heavy Divisions (SACAPO)* on 17 October 1990. This Division oversees the optimal design of the engineer force structure for the Chief of Engineers on the Army Staff. ESSC started the analysis for SACAPO on 7 January 1991. The SACAPO study rates three unit designs. The first design is the Base Case, based on the FY91 force. The second design is the Division Engineer, based on the 1987 E-Force. The third unit design rated by SACAPO is the Regimental Engineer, based on the 1990 E-Force. The Study Advisory Group (SAG) approved the SACAPO report on 16 September 1991.

b. The idea for this study evolved during the SAG meetings for SACAPO on 2 April and 14 August 1991. The sponsor requested that ESSC expand the SACAPO study to determine the number of aircraft sorties and ships required to transport the heavy divisions to SWA. This study is a continuation of the analysis begun in the SACAPO report in July 1991. Only the Base Case and the Regimental Engineer unit designs are studied in this report. The Division Engineer organization rated by SACAPO has been replaced by the Regimental Engineer organization and, therefore, is not evaluated in this study. The three options evaluated for the two remaining unit designs are division zone, division zone with corps plug, and division slice. The remainder of the alternatives and structures defined in the SACAPO report are excluded from this report.

4. ASSUMPTIONS, LIMITATIONS, AND THEIR SIGNIFICANCE.

a. **Assumption.** Deployment assets are unlimited. **Significance.** This study does not examine the need to set priorities or to shuttle aircraft and ships on multiple trips to and from SWA.

b. **Assumption.** Conflicts do not exist with other deploying forces. This study assumes that organizations required to deploy ahead of or after others do so. **Significance.** Movements to ports of embarkation do not overload the capacity of roads, parking facilities, ships, or aircraft.

c. **Assumption.** Level 1 manning and readiness numbers are adequate for planning purposes. **Significance.** This study does not consider Levels 2 and 3. The use of Levels 2 and 3 would reduce the sortie requirements.

d. **Assumption.** The basic load for each unit and additional supplies and ammo are not included. **Significance.** This report does not include the number of aircraft sorties and ships required to move additional supplies and ammo. Including the basic load and additional supplies and ammo will increase the aircraft sortie and ship requirements.

e. **Assumption.** Reduced configurations for equipment are used. An example of reduced configuration is the removal or folding of rotor blades on helicopters before they are loaded on an aircraft. **Significance.** In normal configuration, some equipment must be transported on a C-5, but in reduced configuration, the equipment fits on a smaller C-141. The use of reduced configuration allows more equipment to be placed on one aircraft, thereby reducing the total number of sorties.

f. **Assumption.** The term "critical leg" refers to the longest distance between refueling points for an aircraft. The critical leg for aircraft en route to SWA is 3,500 nautical miles. **Significance.** The need to carry enough fuel to fly 3,500 nautical miles, plus the distance to an alternate airfield, requires reducing the maximum weight of the cargo. This reduction in weight is necessary to comply with Air Force regulations and to remain within aircraft structural weight limitations. A shorter critical leg means an aircraft could carry more cargo, thereby requiring fewer total sorties. A longer critical leg requires either in-flight refueling or less cargo with more total sorties.

g. **Limitation.** This study does not evaluate mobilization and transportation requirements before arrival at ports of embarkation in the U.S. and after arrival at ports of debarkation in SWA. **Significance.** If total mobilization transportation requirements were evaluated, additional aircraft sorties and ships would be required.

5. **METHODOLOGY.** The basic methodology uses unlimited transportation resources for transportation from the U.S. to SWA. The purpose of this study is to determine the number of aircraft and ships necessary to move specified engineer unit designs, not to determine the most efficient departure bases or to prioritize Army forces.

a. **Model Selection.** A decision was made early in this study to use existing organizations and their software to predict sortie information. The alternative for ESSC to develop a concept and to write, test, and implement a computer simulation model was discarded. Research revealed several agencies that could provide portions of the information to ESSC. For this study, the number of aircraft sorties and ships required to transport selected units was determined by the Military Traffic Management Command's (MTMC) Transportation Engineering Agency, Newport News, Virginia. The agency used model simulation systems TARGET to develop aircraft requirements and Unit Movement Requirements for Sealift to develop ship requirements.

b. **Unit Data.** The 1990 Base Case is composed of the following Tables of Organizational Equipment (TOE) engineer units: 05145J410, 05035H500, 05045H100, and 05058H400. The 1999 Regimental Engineer case consists of the following units: 05335L000, 05425L500, 05435L600, and 05423L000. The data for the 1990 engineer units was available on the MTMC system and the October 1990 version was selected to be compatible with the SACAPO report. ESSC obtained the data for 1999 TOE units 05-335L, 05-425L, 05-435L, and 05-423L from the Engineer School at Fort Leonard Wood. The data was electronically reduced to LIN numbers and Level 1 quantities for subsequent transmission to MTMC. MTMC entered the ESSC-furnished data into their TARGET and Unit Movement Requirements for Sealift model simulation systems for analysis. **Figure 2** shows the number and types of battalions that are evaluated by this study. The engineer units for both 1990 and 1999 cases are shown by name and TOE under the Engineer Unit heading. The organizations are evaluated separately by division zone, division zone plus a corps plug, and division slice for both the Base Case and the

Regimental Engineer case. The TOE units must be in whole numbers for the MTMC models to run properly. The fractions shown in Figure 2 are computed off line for aircraft in Section II. In comparison to aircraft, the storage capacity of ships is so great that ESSC elected to round off TOE unit sizes in Section III to enable the ship model to run all options for comparison purposes.

DATE	ENGINEER UNIT	BASE CASE			REGIMENTAL ENGINEER		
		Div. Zone	Corps Plug	Div. Slice	Div. Zone	Corps Plug	Div. Slice
1990	Divisional Battalion: TOE 5-145J/K	5	5	5	-	-	-
	Corps Wheeled Battalion (WHEEL): TOE 5-35H	1	1.5	3	-	-	-
	Corps Mechanized Battalion (MECH): TOE 5-45H	4	7.5	7.5	-	-	-
	Combat Support Equipment Company (CSE): TOE 5-58H	-	-	3	-	-	-
1999	Divisional Battalion: TOE 5-335L	-	-	-	15	15	15
	Corps Wheeled Battalion (WHEEL): TOE 5-425L	-	-	-	-	-	4.3
	Corps Mechanized Battalion (MECH): TOE 5-435L	-	-	-	-	5	6.4
	Combat Support Equipment Company (CSE): TOE 5-423L	-	-	-	-	5	10.7

Figure 2. TABLES OF ORGANIZATION AND EQUIPMENT OPTIONS

II. AIRLIFT REQUIREMENTS

6. **GENERAL.** In this section of the study, the TARGET computer model simulator computes two options for each alternative. Option A uses C-141 and C-5 aircraft sorties. Option B uses C-141 and C-17 aircraft sorties. The use of the C-17 in place of the C-5 in Option B does not suggest that the Air Force plans to replace the C-5 with the C-17. The planned role of the C-17 is to replace the C-130, and at this time, the purchase of the C-17 is in question. Air Force cargo transport standards used in the methodology of this report cover unit integrity, weight restrictions, counting base, and critical leg/crew requirements. These areas are discussed below.

a. **Unit Integrity.** The airlift computer simulation model, TARGET, was run initially both with and without unit integrity. "Unit integrity" means a unit must remain together and cannot be loaded with other units on the same or different aircraft. "Without unit integrity" is defined as allowing units to be separated and mixed with other units on the same aircraft. Theoretically, eliminating the requirement for unit integrity increases loading efficiencies and reduces total sortie requirements. However, as stated under Methodology in Section 1 of this report, the TARGET computer simulation model cannot properly process fractional units. For example, a mechanized engineer unit with a strength of 7.5 times the normal TOE 05045H100 cannot be run by the system. TARGET can only run whole number multiplication factors. Therefore, ESSC decided to present information on unit options computed with unit integrity. Partial unit option information computed without unit integrity is available, but not shown in this report.

b. **Weight Restrictions.** The payload weight used in the model for each aircraft, based on a 3,500 nautical mile critical leg, is 53,200 pounds for the C-141, 151,400 pounds for the C-5, and 122,500 pounds for the C-17.[1]

c. **Counting Base.** An aircraft sortie is normally defined as a takeoff and a landing. For study purposes, a sortie is defined as a takeoff somewhere in the U.S. with a final landing in SWA. The possibility of an aircraft being downloaded at an en-route location is exceptionally small--a remote possibility exists that cargo on board an aircraft with severe maintenance problems could be downloaded to another aircraft. However, the number of aircraft remains constant, including a few spare aircraft. Changing airports may increase the number of sorties (takeoffs and landings), but not the total requirement for aircraft. In this study, *total sorties* equates to the *actual number of aircraft needed.*

d. **Critical Leg and Crew Requirements.** For study purposes, the point of embarkation from the U.S. is Pope AFB, North Carolina, and the point of debarkation in SWA is Dhahran, Saudi Arabia. The actual names of departure and arrival bases are not necessary for the purpose of this study. Changing the point of embarkation and debarkation does not change study findings. The more critical factor is the longest distance between refueling stops, or the critical leg, which is 3,500 nautical miles. In-flight refueling is not considered. The refueling point is Torrejon Air Base, Spain. Flight time between the U.S. and Spain is 8 to 9 hours, depending on wind conditions. Flight time from Spain to Saudi Arabia is also 8 to 9 hours. If a flight crew remains with the aircraft, it takes 48 hours to complete a mission. The Military Airlift Command also flies

[1] C-141 and C-5 Sources: *Military Planning Factors, Air Force PAM 76-2*, May 29, 1987. C-17 Source: McDonnell Douglas Brochure.

missions using a "staging" operation. A staging operation is when a crew flies their normal crew day and remains overnight at an en-route location while another crew takes over the aircraft and continues the mission. Using staging operations, a mission from the U.S. to Saudi Arabia takes 24 hours.

7. **ANALYSIS. Figures 3 and 4** show the number of aircraft sorties that are required to transport only one of each type of engineer unit to SWA in the 1990 Base Case and 1999 Regimental Engineer case. This solution is computed to allow the projection of fractional units in other alternatives. The TARGET model computes two solutions for each alternative. The first solution is the number of C-141 and C-5 sorties required. The second solution calculates the number of C-141 and C-17 sorties required. Although the possibility exists that the C-17 may not be purchased by the Air Force, the program was still run for informational and planning purposes.

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1990	05145J410	DIVISION	1	102	53	112	81
	05035H500	WHEEL	1	106	4	110	4
	05045H100	MECH	1	108	7	109	8
	05058H400	CSE	1	18	16	7	26

Figure 3. SORTIES BY AIRCRAFT FOR EACH TOE -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1999	05335L000	DIVISION	1	28	24	45	27
	05425L500	WHEEL	1	77	7	74	10
	05435L600	MECH	1	85	2	86	2
	05423L000	CSE	1	20	14	19	18

Figure 4. SORTIES BY AIRCRAFT FOR EACH TOE -- (1999)

a. **Division Zone.** **Figures 5 and 6** compare division zone sorties for the 1990 and 1999 cases. The 1990 and 1999 division zone sortie calculations are based on the single-unit numbers in Figures 3 and 4. Under Option A, the total number of aircraft sorties in the 1999 Regimental Engineer (780) is 58 percent of the total sorties in the 1990 Base Case (1,345). Under Option B, the total number of aircraft sorties in the 1999 Regimental Engineer (1,080) is 70 percent of the 1990 Base Case total sorties (1,547). In 1999, the number of C-141 sorties decreases for Option A, while the number of C-5 sorties increases. The model counts more oversized equipment for the 1999 Regimental Engineer case than for the Base Case in 1990. In 1990, 78 percent of the Option A sorties are flown by C-141s and 71 percent of the Option B sorties are flown by C-141s. There is a more equal utilization of types of aircraft in 1999. In Option A, C-141s fly 54 percent of the total sorties in 1999. The same equalizing effect is true for Option B.

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1990	05145J410	DIVISION	5	510	265	560	405
	05035H500	WHEEL	1	106	4	110	4
	05045H100	MECH	4	432	28	436	32
	05058H400	CSE	0	0	0	0	0
	TOTAL SORTIES BY AIRCRAFT			1,048	297	1,106	441
	TOTAL SORTIES			1,345		1,547	

Figure 5. SORTIES BY AIRCRAFT FOR DIVISION ZONE -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1999	05335L000	DIVISION	15	420	360	675	405
	05425L500	WHEEL	0	0	0	0	0
	05435L600	MECH	0	0	0	0	0
	05423L000	CSE	0	0	0	0	0
	TOTAL SORTIES BY AIRCRAFT			420	360	675	405
	TOTAL SORTIES			780		1,080	

Figure 6. SORTIES BY AIRCRAFT FOR DIVISION ZONE -- (1999)

b. **Corps Plug. Figures 7 and 8** compare corps plug sorties for the 1990 and 1999 cases. The sortie calculations in these two figures are based on the single-unit numbers listed in Figures 3 and 4. The 1999 Regimental Engineer corps plug case sortie requirements are less for both Options A and B. Option A is 76.8 percent of the 1990 requirement and Option B is 84.7 percent of the 1990 requirement. Comparing C-141 to C-5 sorties shows a more even distribution in 1999 than in 1990. Option A shows that 82 percent of the total sorties in 1990 and 68 percent of the total sorties in 1999 are flown by C-141s. Option B also shows a more even distribution of C-141s to C-17s in 1999 (decreased to 70 percent from 76.8 percent in 1990).

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1990	05145J410	DIVISION	5	510	265	560	405
	05035H500	WHEEL	1.5	159	6	165	6
	05045H100	MECH	7.5	810	53	818	60
	05058H400	CSE	0	0	0	0	0
	TOTAL SORTIES BY AIRCRAFT			1,479	324	1,543	471
	TOTAL SORTIES			1,803		2,014	

Figure 7. SORTIES BY AIRCRAFT FOR CORPS PLUG -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1999	05335L000	DIVISION	15	420	360	675	405
	05425L500	WHEEL	0	0	0	0	0
	05435L600	MECH	5	425	10	430	10
	05423L000	CSE	5	100	70	95	90
	TOTAL SORTIES BY AIRCRAFT			945	440	1,200	505
	TOTAL SORTIES			1,385		1,705	

Figure 8. SORTIES BY AIRCRAFT FOR CORPS PLUG -- (1999)

c. **Division Slice.** **Figures 9 and 10** compare division slice sorties for the 1990 and 1999 cases. As with the division zone and corps plug sorties, division slice sortie calculations are based on the single-unit numbers in Figures 3 and 4. Options A and B total sorties in the 1999 Regimental Engineer are very similar to the 1990 Base Case total sorties. The Option A Regimental Engineer total sortie requirement decreases by only 8 and is 99.6 percent of the 1990 requirement. The Option B Regimental Engineer total sortie requirement actually increases by 116 and is 105 percent of the 1990 requirements. In Option A, the number of C-141 sorties decreases slightly in 1999 and the number of C-5 sorties increases. In Option A, 82 percent of the total sorties in 1990 are flown by C-141s, and in Option B, 76 percent of the total sorties are flown by C-141s. The ratio of C-141s to C-5s in 1999 is the same (73 percent) for Options A and B.

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1990	05145J410	DIVISION	5	510	265	560	405
	05035H500	WHEEL	3	318	12	330	12
	05045H100	MECH	7.5	810	53	818	60
	05058H400	CSE	3	54	48	21	78
	TOTAL SORTIES BY AIRCRAFT			1,692	378	1,729	555
	TOTAL SORTIES			2,070		2,284	

Figure 9. SORTIES BY AIRCRAFT FOR DIVISION SLICE -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	OPTION A		OPTION B	
				C-141	C-5	C-141	C-17
1999	05335L000	DIVISION	15	420	360	675	405
	05425L500	WHEEL	4.3	331	30	318	43
	05435L600	MECH	6.4	544	13	550	13
	05423L000	CSE	10.7	214	150	203	193
	TOTAL SORTIES BY AIRCRAFT			1,509	553	1,746	654
	TOTAL SORTIES			2,062		2,400	

Figure 10. SORTIES BY AIRCRAFT FOR DIVISION SLICE -- (1999)

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III. SEALIFT REQUIREMENTS

8. **GENERAL.** Ships are assumed to carry enough fuel to make the voyage without refueling. The selection of a departure and arrival port is not necessary to run the MTMC Unit Movement Requirements for the Sealift computer simulation model. The selection of different deep sea ports would not change the results of this study.

a. **Ship Criteria**. As with the aircraft TARGET model, MTMC is able to run the sealift model only with full size units. Unlike aircraft units, projections of alternatives with fractions of a unit are impractical because of the enormous storage space on the ships. Because of the inability of the model to run when using fractions of units, ESSC decided to selectively round the units to eliminate the fractions. By selectively rounding, ESSC maintained the relationship and approximate size of the original structures for both 1990 and 1999. **Figure 11** shows the changes to Figure 2 that are necessary for the ship model to run. After comparing the storage capacities of the ships and aircraft, ESSC decided that accuracy in predicting the number of ships would not suffer when considering the total number of ships involved.

DATE	ENGINEER UNIT	BASE CASE			REGIMENTAL ENGINEER		
		Div. Zone	Corps Plug	Div. Slice	Div. Zone	Corps Plug	Div. Slice
1990	Divisional Battalion: TOE 5-145J/K	5	5	5	-	-	-
	Corps Wheeled Battalion: TOE 5-35H	1	2	3	-	-	-
	Corps Mechanized Battalion: TOE 5-45H	4	7	8	-	-	-
	Combat Support Equipment Company: TOE 5-58H	-	-	3	-	-	-
1999	Divisional Battalion: TOE 5-335L	-	-	-	15	15	15
	Corps Wheeled Battalion: TOE 5-425L	-	-	-	-	-	5
	Corps Mechanized Battalion: TOE 5-435L	-	-	-	-	5	6
	Combat Support Equipment Company: TOE 5-423L	-	-	-	-	5	11

Figure 11. SHIP MODEL TOE OPTIONS

b. **Ship Mixes**. Four ship mixes were compared, and the ships contained in each mix are shown in **Figures 12, 13, 14, and 15**. Three types of ships are used: Fast Sealift Ships (FSS); Roll-on Roll-off (RO/RO); and Breakbulk (BB). The capacity for each ship is listed in square feet (SQFT) and in twenty-foot equivalent units (TEU) for containers. Also, the number of days required to load each ship is shown.

SHIP NAME	TYPE	CAPACITY (SQFT)	CAPACITY (TEU)	DAYS TO LOAD
ALGOL	FSS	206,659	44	2
DENEBOLA	FSS	214,086	46	2
CAPE DECISION	RO/RO	166,019	0	1
AMERICAN EAGLE	RO/RO	198,000	0	1
CAPE HENRY	RO/RO	220,066	0	1
CAPE DOMINGO	RO/RO	166,019	0	1
AMERICAN CONDOR	RO/RO	198,000	0	1
AMBASSADOR	RO/RO	84,596	0	1
CAPELLA	FSS	214,086	46	2
CAPE HORN	RO/RO	220,066	0	1

Figure 12. SHIPS IN MIX ONE

SHIP NAME	TYPE	CAPACITY (SQFT)	CAPACITY (TEU)	DAYS TO LOAD
ALGOL	FSS	206,659	44	2
GULF SHIPPER	BB	51,796	0	4
CAPE ANN	BB	61,267	0	4
LAKE	BB	54,568	0	4
AMERICAN EAGLE	RO/RO	198,000	0	1
CAPE DOMINGO	RO/RO	166,019	0	1
DENEBOLA	FSS	214,086	46	2
SANTA ISABEL	BB	74,323	0	4
CAPE CANAVERAL	BB	52,438	0	4
AMBASSADOR	RO/RO	84,596	0	1
CAPELLA	FSS	214,086	46	2
CAPE HENRY	RO/RO	220,066	0	1
CAPE DECISION	RO/RO	166,019	0	1
CAPE ALEXANDER	BB	61,267	0	4
AGENT	BB	58,195	0	4

Figure 13. SHIPS IN MIX TWO

SHIP NAME	TYPE	CAPACITY (SQFT)	CAPACITY (TEU)	DAYS TO LOAD
SANTA LUCIA	BB	74,323	0	4
SANTA BARBARA	BB	74,323	0	4
LAKE	BB	54,568	0	4
PRIDE	BB	54,568	0	4
GULF SHIPPER	BB	51,796	0	4
GULF TRADER	BB	51,796	0	4
GULF MERCHANT	BB	51,796	0	4
CAPE CANAVERAL	BB	52,438	0	4
CAPE ANN	BB	61,267	0	4
CAPE ALEXANDER	BB	61,267	0	4
CAPE ARCHWAY	BB	61,267	0	4
ADVENTURER	BB	58,195	0	4
AIDE	BB	58,195	0	4
AMBASSADOR	BB	58,195	0	4
SANTA ISABEL	BB	74,323	0	4
SANTA CLARA	BB	74,323	0	4
SANTA CRUZ	BB	74,323	0	4
SCAN	BB	54,568	0	4
SOUTHERN CROSS	BB	54,568	0	4
GULF BANKER	BB	51,796	0	4
GULF FARMER	BB	51,796	0	4
CAPE CANSC	BB	52,438	0	4
CAPE CARTHAGE	BB	52,438	0	4
CAPE ALAVA	BB	61,267	0	4
CALIFORNIA	BB	76,522	0	4
CAPE AVINOF	BB	61,267	0	4
AGENT	BB	58,195	0	4
COMPASS ISLAND	BB	86,441	0	0
OBSERVATION ISLAND	BB	86,441	0	0

Figure 14. SHIPS IN MIX THREE

SHIP NAME	TYPE	CAPACITY (SQFT)	CAPACITY (TEU)	DAYS TO LOAD
ALGOL	FSS	206,659	44	2
DENEBOLA	FSS	214,086	46	2
CAPELLA	FSS	214,086	46	2
BELLATRIX	FSS	206,659	44	2
REGULUS	FSS	206,659	44	2
ALTAIR	FSS	197,094	46	2
ANTARES	FSS	197,094	46	2
FOLLUX	FSS	197,094	46	2

Figure 15. SHIPS IN MIX FOUR

9. **ANALYSIS. Figure 16** shows the ship requirements for a unit design consisting of one unit of each TOE for the 1990 Base Case and the 1999 Regimental Engineer case. This artificial case clearly shows that sealift transportation requirements are less for the planned 1999 Regimental Engineer organization. This generic alternative shows that the 1999 Regimental Engineer case requires 50 percent of the 1990 Base Case ships in mix one; 25 percent of the 1990 Base Case ships in mix two; 67 percent of the 1990 Base Case ships in mix three; and 50 percent of the 1990 Base Case ships in mix four.

<table>
<tr><th>DATE</th><th>TOE</th><th>ENGINEER UNIT</th><th>NUMBER OF UNITS</th><th>SHIP MIX ONE</th><th>SHIP MIX TWO</th><th>SHIP MIX THREE</th><th>SHIP MIX FOUR</th></tr>
<tr><td rowspan="4">1990</td><td>05145J410</td><td>DIVISION</td><td>1</td><td rowspan="4">2</td><td rowspan="4">4</td><td rowspan="4">6</td><td rowspan="4">2</td></tr>
<tr><td>05035H500</td><td>WHEEL</td><td>1</td></tr>
<tr><td>05045H100</td><td>MECH</td><td>1</td></tr>
<tr><td>05058H400</td><td>CSE</td><td>1</td></tr>
<tr><td rowspan="4">1999</td><td>05335L000</td><td>DIVISION</td><td>1</td><td rowspan="4">1</td><td rowspan="4">1</td><td rowspan="4">4</td><td rowspan="4">1</td></tr>
<tr><td>05425L500</td><td>WHEEL</td><td>1</td></tr>
<tr><td>05435L600</td><td>MECH</td><td>1</td></tr>
<tr><td>05423L000</td><td>CSE</td><td>1</td></tr>
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Figure 16. NUMBER OF SHIPS FOR GENERIC ALTERNATIVE

a. **Division Zone**. **Figures 17 and 18** compare the number of ships for division zone in the 1990 and 1999 cases. This comparison reveals that the Regimental Engineer organization requires fewer ships in all four ship mixes--only 67, 75, 71 and 80 percent of the division zone ships in the 1990 Base Case are required for the 1999 Regimental Engineer division zone case. To interpret the figures, first note the number of ships listed under the ship mix column; e.g., 6 ships for mix one in Figure 17. Using the number 6, refer to Figure 12 and note the first 6 ships listed in mix one. In this instance, the ships used by the model are Algol, Denebola, Cape Decision, American Eagle, Cape Henry, and Cape Domingo. The rest of the ships on the mix-one list are not required for this alternative package.

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	SHIP MIX ONE	SHIP MIX TWO	SHIP MIX THREE	SHIP MIX FOUR
1990	05145J410	DIVISION	5	6	8	17	5
	05035H500	WHEEL	1				
	05045H100	MECH	4				
	05058H400	CSE	0				

Figure 17. NUMBER OF SHIPS FOR DIVISION ZONE -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	SHIP MIX ONE	SHIP MIX TWO	SHIP MIX THREE	SHIP MIX FOUR
1999	05335L000	DIVISION	15	4	6	12	4
	05425L500	WHEEL	0				
	05435L600	MECH	0				
	05423L000	CSE	0				

Figure 18. NUMBER OF SHIPS FOR DIVISION ZONE -- (1999)

b. **Corps Plug**. **Figures 19 and 20** compare the ship requirements for the division zone with corps plug alternative in the 1990 and 1999 cases. This comparison reveals little difference in requirements between the 1990 and 1999 cases. The 1999 Regimental Engineer unit design requires slightly fewer ships in each of the four mixes--ship mix one is 86 percent of the 1990 Base Case requirements, ship mix two is 91 percent of the 1990 requirements, ship mix three is 83 percent of the 1990 requirements, and ship mix four is 86 percent of the 1990 Base Case requirements.

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	SHIP MIX ONE	SHIP MIX TWO	SHIP MIX THREE	SHIP MIX FOUR
1990	05145J410	DIVISION	5	7	11	23	7
	05035H500	WHEEL	1				
	05045H100	MECH	4				
	05058H400	CSE	0				

Figure 19. NUMBER OF SHIPS FOR CORPS PLUG -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	SHIP MIX ONE	SHIP MIX TWO	SHIP MIX THREE	SHIP MIX FOUR
1999	05335L000	DIVISION	15	6	10	19	6
	05425L500	WHEEL	0				
	05435L600	MECH	5				
	05423L000	CSE	5				

Figure 20. NUMBER OF SHIPS FOR CORPS PLUG -- (1999)

c. **Division Slice.** **Figures 21 and 22** compare the ship requirements for the division slice alternative in 1990 and 1999. The comparison reveals that 1999 requirements increase in all ship mixes, except ship mix two. Ship mix one 1999 requirements are 11 percent greater than the 1990 requirements; ship mix two requirements for 1999 and 1990 are the same; ship mix three 1999 requirements are 7 percent greater than the 1990 requirements; ship mix four 1999 requirements are 13 percent greater than the 1990 requirements. The "*-1*" number shown under ship mix four means the computer solution was one ship more than the available ships shown in Figure 15.

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	SHIP MIX ONE	SHIP MIX TWO	SHIP MIX THREE	SHIP MIX FOUR
1990	05145J410	DIVISION	5	9	13	27	8
	05035H500	WHEEL	1				
	05045H100	MECH	4				
	05058H400	CSE	0				

Figure 21. NUMBER OF SHIPS FOR DIVISION SLICE -- (1990)

DATE	TOE	ENGINEER UNIT	NUMBER OF UNITS	SHIP MIX ONE	SHIP MIX TWO	SHIP MIX THREE	SHIP MIX FOUR
1999	05335L000	DIVISION	15	10	13	29	-1*
	05425L500	WHEEL	0				
	05435L600	MECH	5				
	05423L000	CSE	5				

** Indicates 1 more than the available 8 ships listed in Ship Mix 4 or a total of 9 ships.*

Figure 22. NUMBER OF SHIPS FOR DIVISION SLICE -- (1999)

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IV. CONCLUSIONS AND RECOMMENDATIONS

10. **BASE CASE VERSUS REGIMENTAL ENGINEER. Figure 23** summaries (as percentages) the transportation requirements found in Sections II and III of this report. For comparison purposes, the Base Case is 100 percent of the transportation assets requirements. Figure 23 shows the 1999 Regimental Engineer case as a percentage of the 1990 Base Case. For example, the transportation requirement for the Regimental Engineer division zone unit Option A is 58 percent of the Base Case Option A requirement. The 1999 Regimental Engineer corps plug and division slice Option A requirements are 76.8 and 99.6 percent, respectively, of the 1990 Base Case Option A transportation requirements. The sealift percentages shown in Figure 23 are the computed averages of all four ship mixes in each unit option. For example, in Figures 17 and 18, the division zone percentages for the four ship mixes are 67, 75, 71, and 80, and the average is 73.3 percent. The corps plug and division slice are shown as 86.5 and 107.8 percent respectively.

MODE	UNIT OPTION	1999 REGIMENTAL ENGINEER CASE (PERCENT OF 1990 BASE CASE)
AIRLIFT	DIVISION ZONE	58.0
	CORPS PLUG	76.8
	DIVISION SLICE	99.6
SEALIFT	DIVISION ZONE	73.3
	CORPS PLUG	86.5
	DIVISION SLICE	107.8

Figure 23. DEPLOYMENT COMPARISONS

11. **CONCLUSIONS.** Because the 1999 Regimental Engineer unit structure is smaller in total size than the 1990 Base Case unit structure, the transportation requirements are, therefore, less for the division zone and corps plug. However, the division slice unit option transportation requirements are greater in 1999 than in 1990 because of the additionally assigned engineer units.

a. **Division Zone**. Of the unit options, the division zone consistently requires fewer air and sea transportation resources. The division zone area on the battlefield is the smallest of the three unit options and the engineer force within the area is also the smallest. Therefore, transportation requirements for transporting the smaller engineer force to SWA are also the least.

b. **Corps Plug**. The corps plug unit option requires more aircraft sorties and ships than the division zone unit option, but less than the division slice option. However, the Regimental Engineer unit structure requires fewer transportation resources than the Base Case.

c. **Division Slice**. The 1999 Regimental Engineer division slice unit option requires almost the same number of aircraft sorties (2,062) as the 1990 Base Case (2,070). It requires more ships in mixes one, three, and four (see Figures 21 and 22) than the 1990 Base Case. The average percentage increase is 7.8.

12. **RECOMMENDATIONS.** The current draw down in all DOD organizations, forces, and overseas locations will have a significant impact on future transportation assets. If history repeats itself, the missions and responsibilities of the Corps of Engineers will remain constant or increase. At the same time, the strength and size of our forces will be reduced. Smaller and more capable engineer organizations will be required.

a. Transportation should be a major component of the planning process for future engineer organizational structures. Also, maintaining a continuous dialogue with the MTMC Transportation Engineering Agency should be a standard part of the planning process. The fine tuning of engineer unit structures and equipment should be proactive rather than reactive to transportation realities.

b. Much effort and planning to reduce the size of the Corps has already taken place. A full 1999 Regimental Engineer division slice should have transportation requirement reductions approaching the number gained within the 1999 Regimental Engineer division zone. Given the results of this study and the earlier SACAPO study, engineer planners should not only continue their efforts to downsize the engineer force, but should also strive for a greater reduction of future Corps transportation asset requirements. Engineer planners can use our findings as a heads-up notification of future transportation problems. They can tailor changes in unit sizes and allocations to match future transportation capabilities.

LAST PAGE OF STUDY

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